Draft

Field-Scale Demonstration Study Results Report for Operable Unit 8 Pilot Study

American Cyanamid Superfund Site

Prepared for

Pfizer Inc., on behalf of Wyeth Holdings LLC

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Revised

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Acronyms and Abbreviations

APA	air pathway analysis
BGMWP	*Baseline Groundwater Monitoring Work Plan*
DOT	Department of Transportation
EIPT	Environmental Improvement Pilot Test
ISS	in-situ stabilization and solidification
ISTT	in-situ thermal treatment
OU8	Operable Unit 8
PID	photoionization detector
ppbv	parts per billion by volume
RCRA	Resource Conservation and Recovery Act
Site	American Cyanamid Superfund Site in Bridgewater, New Jersey
SVOC	semivolatile organic compound
TVOC	total volatile organic compound
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

SECTION 1

Introduction

Wyeth Holdings LLC conducted a pilot study program within Impoundment 2 for Operable Unit 8 (OU8) at the American Cyanamid Superfund Site in Bridgewater, New Jersey (Site) in accordance with the *100 Percent Design of Pilot Study for Operable Unit 8*, which was approved by the United States Environmental Protection Agency (USEPA) on December 12, 2013 and the following project plans, which have been developed in support of this pilot study:

- *Technical Memorandum Soil Erosion and Sediment Control Plan for Operable Unit 8 Pilot Study* (CH2M HILL 2013a) – Approved by USEPA on August 1, 2012
- *Health and Safety Plan, American Cyanamid Superfund Site, Impoundments 1 and 2, In-Situ Thermal Treatment and In-Situ Stabilization and Solidification, Pilot Study for Operable Unit 8* (CH2M HILL 2013b) – Approved by USEPA on September 12, 2013
- *Waste Management Plan for Operable Unit 8 Impoundments 1 and 2 Pilot Study* (CH2M HILL 2013c) – Approved by USEPA on September 12, 2013
- *Quality Assurance Project Plan Pilot Study for Operable Unit 8* (CH2M HILL 2013d) – Approved by USEPA on November 14, 2013
- *Sampling and Analysis Plan for Operable Unit 8 Pilot Study* (CH2M HILL 2013e) – Approved by USEPA on November 14, 2013
- *Perimeter Air Monitoring Plan for Operable Unit 8 Pilot Study* (CH2M HILL 2013f) – Approved by USEPA on November 14, 2013
- *100 Percent Design of Pilot Study for Operable Unit 8* (CH2M HILL 2013g) – Approved by USEPA on December 12, 2013
- *Site-Specific Work Plan In-Situ Thermal Treatment and In-Situ Stabilization and Solidification* (CH2M HILL 2013h) – Approved by USEPA on December 12, 2013
- *Addendum to Flood Emergency Procedures Plan Impoundments 1 and 2 Pilot Study for Operable Unit 8* (CH2M HILL 2013i) – Approved by USEPA on December 12, 2013
- *Emergency Preparedness and Contingency Plan* (CH2M HILL 2013j) – Approved by USEPA on January 9, 2014
- *Technical Memorandum - Sampling and Analysis Plan Proposed Changes Acid Gas Sampling Procedures and Frequencies* – submitted to USEPA on January 31, 2014 (CH2M HILL 2014a)
- *Technical Memorandum - Sampling and Analysis Plan Addendum* – submitted to USEPA May 16, 2014 (CH2M HILL 2014b)

This report summarizes the pilot study activities and presents the results of environmental monitoring and sampling conducted in accordance with the USEPA-approved project plans for the duration of the pilot study. In accordance with the Administrative Settlement Agreement and Order of Consent for Remedial Design, Operable Unit 4 and Focused Feasibility Study, Operable Unit 8 (USEPA 2013), this *Field-Scale Demonstration Study Results Report* is being submitted to USEPA within 9 months of approval of the *100 Percent Design of Pilot Study for Operable Unit 8* (CH2M HILL 2013g), which USEPA approved on December 12, 2013.

SECTION 2

Civil Infrastructure Construction

Civil infrastructure construction activities were initiated at the Site in August 2013 and included the following activities:

- Construction of the elevated equipment bench along the western side of Impoundment 2, including gabion basket wall, safety railing, and secondary containment
- Construction of the crane bench in the northwestern corner of Impoundment 2
- Construction of the weir box on the berm between Impoundments 1 and 2
- Installation of helical screw anchors into the ground beyond the berms of Impoundment 2
- Mobilization of the Flexifloats to the Site and installation of the safety rails and winches onto the Flexifloats
- Placement and assembly of the Flexifloats within Impoundment 2
- Installation of Blue Dyneema rope from winches to helical screw anchors
- Installation of the three steel caissons onto the Flexifloat platform
- Installation of the step-down electrical transformer
- Installation of the backup generator

Infrastructure construction activities were completed on October 24, 2013. Additional construction activities, documented as deviations from the *Site-Specific Work Plan* (CH2M HILL 2013h), included raising and lowering the caissons after installation to increase the tar levels within the caissons and additional investigation efforts to determine the types of material present in each caisson after installation. These activities were documented in the *Caisson Placement and Impoundment Material Characterization Memorandum* (CH2M HILL 2013k).

SECTION 3

In-Situ Thermal Treatment

Following completion of infrastructure construction, mobilization and installation of the in-situ thermal treatment (ISTT) system was conducted through February 2014. Installation of the ISTT system components consisted of the following activities:

- Installation and testing of the thermal oxidizer and caustic scrubber system
- Installation and testing of the zeolite secondary vapor treatment system
- Installation and testing of the pH neutralization and sorption liquid treatment system
- Installation of the heater wells and multiphase extraction wells
- Installation and testing of the caisson temperature monitoring and control systems
- Installation of the nitrogen and propane supply tanks
- Installation of additional components for the thermal treatment system (such as blowdown tanks, scrubber, boiler, etc.)
- Installation and testing of piping for water, steam, and nitrogen extending from the Flexifloat platform to the equipment bench
- Installation and testing of various system components and sensors including oxygen sensors, water flow control interlocks, overall electrical system, flammability lower explosive limit analyzer
- Installation of the corrosion coupons for material capability testing
- Installation and integration of software and control system for thermal treatment components

The ISTT system comprised heater wells, vapor extraction wells, multiphase extraction wells, temperature monitoring points, nitrogen injection wells, and steam injection wells. Additional information regarding installation, function, and operation of these components is documented in the *In-Situ Thermal Treatment Pilot Study Final Report* (TerraTherm 2014) provided in Attachment 1. Upon completion of system construction, component integration, testing, and installation troubleshooting were conducted through system startup on February 28, 2014. Specific tasks included the following:

- Pressure testing of system piping and vacuum extraction lines
- Testing and verification of interlocks and controls
- Setup and calibration of system monitoring instruments
- Integration and testing of nitrogen injection system
- Heat tracing and insulation of scrubber conveyance lines, caisson piping, and cover
- Condensate collection system installation
- Temperature monitoring system installation in boiler room and hydronic heating circuits

On February 7, 2014, during thermal oxidizer commissioning activities, it was determined that a cooling blower had malfunctioned resulting in damage to the thermal oxidizer burner assembly. The burner was replaced on February 17, 2014, and commissioning activities continued. Following a detailed examination of system components and final process checks, caisson headspace vapors were introduced to the oxidizer on February 27, 2014. The following day, February 28, 2014, heaters in Caissons 2 and 3 were activated.

The ISTT system was shut down on March 3, 2014, to replace a magnifying lens in the thermal oxidizer and was shut down on March 6, 2014, when operations staff identified gaskets that were leaking on the vacuum blower discharge. Following replacement of these gaskets and inspection of the vapor piping system for leaks, heating operations resumed on March 10, 2014.

Operation of the ISTT system continued from March 10, 2014 through system shutdown on May 9, 2014 with limited periods of shutdown to support inspection, calibration, and maintenance procedures by site operations staff. Shutdowns generally were of limited duration (a few hours) and are considered insignificant events in the pilot study timeline. Details of system shutdowns are summarized in the TerraTherm operations report presented in Attachment 1. It should be noted that none of these system shutdowns triggered a notification or action level as defined by the PAMP (see Section 5.1).

ISTT operations were conducted in accordance with an Environmental Improvement Pilot Test (EIPT) permit equivalent issued by the New Jersey Department of Environmental Protection (NJDEP) on January 15, 2014 (EIP130001) and a second EIPT permit equivalent issued on April 15, 2014 (EIP140001). The second EIPT was terminated on May 9, 2014, with the conclusion of the ISTT portion of the pilot study.

The ISTT equipment was demobilized starting on May 10, 2014, including the removal of infrastructure on the Flexifloats to allow access for equipment required for the in-situ stabilization and solidification (ISS) phase of the pilot study. Decommissioning included removing and decontaminating piping, controls, wiring, insertion heaters, etc.

SECTION 4

In-Situ Stabilization and Solidification and Impoundment Material Sampling

Mobilization and installation of the ISS system was initiated on May 18, 2014. Mobilization activities included:

- Construction of decontamination pad
- Installation of ISS subcontractor office trailer with the necessary utilities
- Mobilization and assembly of ISS mixing equipment
- Preparation of reagents and mixing blends

Following mobilization, ISS mixing operations for Caissons 1 and 3 were completed between May 29, 2014 and June 6, 2014. The sequence of ISS operations for each caisson were as follows:

Summary of ISS Operations for Caisson 1

- May 30, 2014 - Homogenization of material
- May 30, 2014 - pH buffering with a slurry of hydrated lime
- May 30, 2014 – Primary ISS mixing with Partac Clay, Lafarge NewCem, and OMNI fluidized bed ash
- June 4, 2014 – Excavation of material from Caisson 1 into rolloff container
- June 5, 2014 – Secondary mixing of Portland cement into Caisson 1 material in rolloff container
- June 6, 2014 – Transfer of Caisson 1 material from unlined rolloff container to lined rolloff container

Summary of ISS Operations for Caisson 3

- May 29, 2014 - Homogenization of material
- May 29, 2014 - pH buffering/de-emulsification with a slurry of lime kiln dust
- May 29, 2014 – Primary ISS mixing using Lafarge NewCem grout
- June 4, 2014 – Excavation of material from Caisson 3 into rolloff container
- June 4, 2014 – Secondary mixing of Portland cement into Caisson 3 material in rolloff container
- June 5, 2014 – Transfer of Caisson 3 material from unlined rolloff container to lined rolloff container

The ISS equipment was demobilized starting on June 10, 2014, including removing and decontaminating process and rental equipment and other remaining aboveground infrastructure located on or near the equipment bench. Final demobilization of ISS equipment and personnel was completed on June 19, 2014. Additional details regarding the ISS phase of the pilot study are provided in the *In-Situ Solidification and Stabilization for Operable Unit 8 Pilot Study Construction Completion Report* (WRS 2014) provided in Attachment 2a.

Following removal and ISS mixing operations, the lined and covered rolloff containers were staged in the North Area of the Site for subsequent transportation cement kiln and incinerator facilities for further testing and disposal. Caisson removal and decontamination activities commenced during the week of June 9, 2014, and were completed by June 27, 2014.

ISS operations were conducted in accordance with an EIPT permit equivalent issued by NJDEP on May 9, 2014 (EIP130002). This EIPT was terminated on June 27, 2014, with the conclusion of the pilot study.

4.1 Impoundment Material Sampling

Impoundment material sampling was conducted in accordance with the USEPA-approved sampling and analysis plan (CH2M HILL 2013e) and the May 2014 sampling and analysis plan addendum (CH2M HILL 2014b). Table 1 provides a detailed summary of sample locations and analytical parameters for impoundment material samples collected during the pilot study.

4.1.1 Baseline Sampling

The baseline samples of untreated impoundment material were collected from the caissons November 19 through 21, 2013, in accordance with the USEPA-approved sampling and analysis plan (CH2M HILL 2014a). Additional baseline sampling was conducted in Caisson 1 (TC-01A and TC-01B) on May 19-20, 2014. Samples were collected from each of the caisson test cells (TC-01, TC-02, and TC-03) as shown on Figure 1 and submitted for testing of chemical and physical analysis as outline in Table 1.

4.1.2 Post-ISTT, Pre-ISS Sampling

Post-ISTT and pre-ISS sampling for impoundment materials was conducted using Vibracore technology on May 19 and May 20, 2014, from one location in Caisson 2 (TC-02) as shown on Figure 2. Because of limitations of the Vibracore drilling method posed by physical conditions within thermally treated caissons, a sonic drilling rig was mobilized for sample collection in Caissons 2 and 3 from May 27 through May 30, 2014. The sonic drilling method was used for collecting samples from three locations in Caisson 2 (TC-02A, TC-02B, and TC-02C) and three locations (TC-03A, TC-03B, and TC-03C) as depicted on Figure 2. Samples from both drilling events were collected and submitted for chemical and physical analyses as outlined in Table 1. The cores and grab samples were visually characterized for impoundment material type, color, moisture presence, texture, grain size and shape, consistency, visible evidence of staining, and other observations. Impoundment material logs with corresponding digital photographs of each core sample are provided in Attachment 2b.

4.1.3 Post-Primary ISS Sampling

Post-primary ISS sampling was conducted in Caissons 1 and 3 on May 30 and May 29, 2014, respectively. Impoundment material samples were collected using Vibracore technology from two locations in Caisson 1 (TC-01A and TC-01B) and from three locations in Caisson 3 (TC-03A, TC-03B, and TC-03C) as shown on Figure 2. Samples from both events were collected and submitted for chemical and physical analyses. The cores and grab samples were visually characterized for impoundment material type, color, moisture presence, texture, grain size and shape, consistency, visible evidence of staining, and other observations. Impoundment material logs with corresponding digital photographs of each core sample are provided in Attachment 2b.

4.1.4 Post-Secondary ISS Sampling

Post-secondary ISS sampling activities were conducted June 4 and June 5, 2014. Samples were collected from Caisson 1, Caisson 2 (post-removal), and Caisson 3 and submitted for chemical, physical, and waste characterization analyses including thermal stability and Department of Transportation (DOT) testing as outlined in Table 1. Sample locations during removal and secondary mixing are shown on Figure 1.

A summary of validated chemical data for impoundment material analytical results and non-validated analytical packages for DOT testing is included in Attachment 2b. Note that the ANSI test for impoundment material samples is a 90-day test, which was started on July 28, 2014, and is still ongoing at the laboratory. ANSI test results will be provided as an addendum to this report once the tests are completed, samples analyzed, and data are validated. A CD containing final laboratory data packages is included in Attachment 7.

4.2 Air Pathway Analysis

An air pathway analysis (APA) was conducted in accordance with the May 2014 sampling and analysis addendum (CH2M HILL 2014b). Testing was conducted on impoundment material at various stages of the pilot study as shown in Table 1 using the USEPA Surface Emission Isolation Flux Chamber. APA testing of the impoundment material surface within each caisson was conducted on May 19 and May 20, 2014. These tests were performed following thermal treatment in Caissons 2 and 3 and before ISS treatment in Caissons 1 and 3. APA testing also was conducted on June 10, 2014, on cores collected from Caisson 2 (post-thermal) and from Caissons 1 and 3 (following primary and secondary ISS operations). At each of the emissions testing locations, 1-liter SUMMA canister grab samples for volatile organic compound (VOC)

analysis and 1-liter glass-lined Bottle-Vac samples for reduced sulfur compounds analysis were collected. The *Technical Memorandum - Assessment of volatile organic compound and sulfur compound emissions using the USEPA surface emission isolation flux chamber* (Schmidt 2014) provided in Attachment 2c contains additional information pertaining to emission sample collection and observations. A summary of validated emissions testing data and final data packages are included in Attachment 2c.

SECTION 5

Perimeter Air Monitoring Program

5.1 Real-Time Perimeter Air Monitoring

Installation of the perimeter air monitoring network was completed in December 2013. In accordance with the *Perimeter Air Monitoring Plan* (CH2M HILL 2013f), baseline real-time perimeter air monitoring was conducted for approximately 1 week from December 16 through December 22, 2013.

During the pilot study, 10 real-time perimeter air monitoring stations were installed for real-time monitoring. Locations of the stations are shown on the site map (Figure 1). Two different zones of monitoring locations were established based on proximity to the pilot study area and were designated as follows:

- Zone 1: Five stations in the work area, identified as C1 through C5
- Zone 2: Five stations at the perimeter or near adjacent receptors, identified as I1 through I5

Each monitoring station included real-time air monitoring devices for both total volatile organic compounds (TVOCs) by (PPB RAE Model 3000) and hydrogen sulfide meter by (Jerome Model 631X). As outlined in the *Perimeter Air Monitoring Plan* (CH2M HILL 2013f), two concentration thresholds were established for TVOCs and reduced sulfur that required actions to be performed:

- Notification Level – This level was set at 1,000 parts per billion by volume (ppbv) for TVOCs and 100 ppbv for reduced sulfur and was established to confirm the source and determine if the excursion was related to pilot study activities.
- Action Levels – This level was set at 3,000 ppbv for TVOCs and 800 ppbv ppm for reduced sulfur and was established to identify the potential source and implement control measures effective in reducing cause of elevated emissions, including potential shutdown of the pilot study as necessary given numeric observations.

Each of the Zone 1 photoionization detector (PID) monitors also was equipped with a pre-filter that allowed for speciation of benzene. If notification or action levels were reached during pilot study operations, the pre-filter enabled the PID monitors to determine how much of the TVOC reading was attributed to benzene. In instances where an action level was observed, a grab sample was collected and analyzed for VOCs and reduced sulfur compounds in accordance with the *Perimeter Air Monitoring Plan* (CH2M HILL 2013f).

During ISS, the perimeter air monitoring program was supplemented to include real-time air monitoring of particulates during mixing. Particulate monitoring was conducted using a handheld meter during ISS operations.

In advance of system startup, the real-time perimeter air monitoring network was operated in January 2014 to augment collection of baseline data. During this period, intermittent shutdowns of the air monitoring station were required for emergency backup generator testing (AC-powered stations) and in locations where battery charge could not be maintained by solar panels located at remote stations because of low sunlight. With the exception of intermittent shutdowns because of site conditions, air monitoring equipment and telemetry network operated continuously during the pilot study. A summary of system shutdowns and action levels observed during the pilot study perimeter real-time air monitoring is as follows:

- On February 7, 2014, the perimeter air monitoring network was temporarily suspended during the burner repair activities previously described. The stations were placed back in service on February 21, 2014, after the burner was replaced, and system commissioning continued.
- On April 30, 2014, the system was removed from service because of emergency flood conditions at the Site. The system was placed back in service on May 5, 2014.

- On May 30, 2014, a TVOC action level was observed at C5 (on the Flexifloat platform) that appeared associated with pilot study operations between completion of thermal operation and the start of mixing. Following an evaluation of Site conditions at the time of excursion (rain/fog were present), the monitoring system operation was cycled on several occasions to confirm station output. However, operator inspection confirmed the excursion was attributed to an auger after it was removed from Caisson 1 following mixing. The reading was confirmed with a handheld detector, and a vapor sample was collected for laboratory analysis in accordance with *Perimeter Air Monitoring Plan* procedures (CH2M HILL 2013f). Note that no notification or action level was observed at Zone 2 air monitoring stations during this event. USEPA personnel (Angela Carpenter and Harry Compton) were onsite during this activity and were notified immediately of the action level.
- On June 4, 2014, a TVOC action level was observed at C5 (on the Flexifloat platform) that appeared to be associated with pilot study operations during excavation of impoundment material from Caisson 1 or from the placement/storage of excavated material in a rolloff container. The reading was confirmed with a handheld detector, and a sample was collected for laboratory analysis in accordance with *Perimeter Air Monitoring Plan* procedures (CH2M HILL 2013f). Note that no notification or action level was observed at Zone 2 air monitoring stations during this event. Mark Austin of USEPA was notified of the action level immediately via telephone followed by email on June 4, 2014, at 5:53 p.m.
- Between June 12 and June 15, 2014, the monitoring system was taken offline because of a prolonged period of damp and rainy weather. Throughout the pilot study, these atmospheric conditions were routinely associated with concentration excursions that could not be reproduced by site operations staff using independent handheld monitoring devices.

The real-time perimeter air monitoring network was shut down on June 27, 2014, following caisson removal and decontamination activities and completion of the pilot study activities. In general, elevated readings were observed occasionally over the perimeter air monitoring period. When observed, notification or action levels were because of instrument drift, false readings from temperature and humidity, or transient excursions that quickly returned to baseline readings consistent with background conditions. A summary report of perimeter air monitoring data and further discussion of both notification and action level readings observed throughout the pilot study monitoring period is provided in Attachment 3a.

5.2 Ambient Air Sampling

In accordance with the *Perimeter Air Monitoring Plan* (CH2M HILL 2013f), baseline ambient air sampling was conducted from December 16 through December 20, 2013. Four ambient air locations were sampled during the baseline event: one in the work zone area near the process operations and three at real-time perimeter stations I2, I4, and I5 (Figure 1). Three samples were collected from each location, for a total of 12 samples, and submitted for the laboratory analysis outlined below. Continuous 24-hour SUMMA canister samples were collected for VOC analysis by USEPA Method TO-15 at each of the four sampling locations. Grab samples were collected for reduced sulfur compounds analysis by ASTM International D5504 method using 1-liter Tedlar bags at each of the four sampling locations.

Ambient air samples were not collected during January and February 2014 because ISTT operations did not commence until February 27, 2014. Ambient air sampling resumed in March 2014 following ISTT system startup and was conducted every 3 weeks during pilot study operations through June 2014. During pilot study operations, ambient air samples were collected at four locations: one in the work zone area near the process operations and at each of the perimeter stations I2, I4, and I5. Continuous 24-hour SUMMA canisters samples for TO-15 analysis and 1-liter Tedlar bag grab samples for reduced sulfur compounds were collected at each of the four sampling locations.

The following is a summary of sampling deviations in ambient air sampling including supplemental sample collection resulting from site-specific conditions:

- A continuous 24-hour SUMMA canister sample was collected on March 13, 2014, to support evaluation of air quality near process operations. The results indicated the VOC concentration surrounding working areas of process operations and the thermal oxidizer were below exposure limits defined in the *Health and Safety Plan* (CH2M HILL 2013b).
- Pilot study ambient air sampling was conducted on April 10 and April 11, 2014. The next ambient air sampling event was scheduled for the week of April 28, 2014; however, because of emergency flood conditions at the Site, that ambient air event was conducted during the first week in May 2014.
- An additional round of ambient air sampling was conducted in May 2014 during ISS mixing operations on May 29 and May 30, 2014.
- A grab sample was collected for VOC and reduced sulfur compounds at perimeter air monitoring location C5 (located on the Flexifloat platform) on May 30, 2014, in response to an action level observed during ISS mixing as discussed in Section 5.1. Note that no notification or action level was observed at Zone 2 air monitoring stations during this event.
- A grab sample was collected for VOC and reduced sulfur compounds at perimeter air monitoring location C5 (located on the Flexifloat platform) on June 4, 2014, in response to an action level observed during removal of material from Caisson 1 as discussed in Section 5.1. Note that no notification or action level was observed at Zone 2 air monitoring stations during this event.

A round of ambient air sampling was conducted during ISS secondary mixing operations on June 5 and June 6, 2014. A final ambient air event was conducted June 16 and June 17, 2014. A summary of validated ambient air data is in Attachment 3b. A CD containing final laboratory data packages is in Attachment 7.

SECTION 6

Water Cap Sampling

Baseline water cap samples were collected before caisson installation on October 29, 2013, and 24 hours after caisson installation on October 30, 2013, in accordance with the USEPA-approved sampling and analysis plan (CH2M HILL 2014a). Additional baseline water cap samples were collected on November 12, 2013. During each sampling event, water cap samples were collected from four locations (SW-01, SW-02, SW-03, and SW-404) from Impoundment 2 and two locations (SW-05 and SW-06) from Impoundment 1 (Figure 1). Water cap samples were submitted for analytical analysis of VOCs, semivolatile organic compounds (SVOCs), and total metals.

Water cap sampling was not conducted during January and February 2014 because the impoundment surfaces were frozen. In addition, ISTT operations had not yet commenced. Water cap sampling was implemented weekly from accessible locations starting in March 2014 and continued through June 2014. A final water cap sampling event was conducted during caisson removal on June 24, 2014. A summary of non-validated water cap data and trend graphs is in Attachment 5. A CD containing final laboratory data packages is in Attachment 7.

SECTION 7

Impoundment 2 Groundwater Sampling

Monitoring of groundwater near Impoundments 1 and 2 was performed in accordance with the *Impoundment 2 Baseline Groundwater Monitoring Work Plan* (BGMWP; Golder 2013). The objective of the Impoundment 2 BGMWP was to install a new piezometer network proximate to Impoundment 2 and implement a monitoring program designed to provide information to identify any potential groundwater impacts attributable to the OU8 pilot study.

Based on the results of five rounds of groundwater sampling and real-time monitoring of the piezometer network, the ISTT activities associated with the pilot study likely have not influenced the surrounding groundwater quality indicator parameters. Similar to the baseline monitoring period, natural influences (such as ambient air temperature and precipitation events) appear to have had the greatest impact on the water quality indicator parameters. During operation of the ISTT system, there were no appreciable increases in groundwater temperature at any piezometers in the monitoring program. As noted during the baseline monitoring period, the groundwater temperature is influenced primarily by the ambient air temperature. The pH remained stable in upgradient and downgradient monitoring locations. It is believed that increased temperature and depressed pH would be the strongest indicators of impacts related to the pilot-scale study. Conductivity remained stable in upgradient and downgradient monitoring locations. Conductivity inflections quickly return to baseline conditions and are attributable to precipitation events. Turbidity, dissolved oxygen, and oxidation-reduction potential showed the most variability during baseline monitoring and post-startup monitoring. Similar to temperature, pH, and conductivity, these inflections quickly return to baseline conditions and are a result of precipitation events. PID readings remained stable in all monitoring locations, most notably the piezometers closest to the ISTT zone.

Post-ISTT groundwater analytical results demonstrate that increases in concentrations were not observed when compared to baseline concentrations. Post-ISTT groundwater analytical results also demonstrate reduced concentrations of VOCs, SVOCs, and metals in downgradient wells when compared to previous monitoring events and baseline data. Upgradient monitoring wells did not demonstrate increases or decreases in concentration. The pH, at the time of sampling and as measured via in-well data loggers, in PZ-12-10 increased 2.0 standard units. Consistent with data from routine semiannual groundwater monitoring in the South Area, groundwater elevation has increased over time in all piezometers, upgradient and downgradient of Impoundment 2. In summary, the groundwater analytical and monitoring results indicate there were no negative impacts to groundwater quality from the OU8 pilot study activities proximate to Impoundment 2.

Additional details regarding the groundwater monitoring program are provided in the *Impoundment 2 Baseline Groundwater Monitoring Program Final Report* (Golder 2014) provided in Attachment 4.

SECTION 8

Additional Sampling and Monitoring

8.1 Process Vapor Sampling

Process vapors were monitored and sampled throughout the pilot study to track mass removal from the caissons during ISTT and ISS operations. As outlined in the sampling and analysis plan (CH2M HILL 2014a), process vapor sampling was initiated during system startup on February 28, 2014, and continued through system shutdown on May 9, 2014. In accordance with the sampling and analysis plan (CH2M HILL 2014a), effluent samples from the thermal oxidizer were collected daily from startup through March 23, 2014. The sample frequency then was reduced to every other day from March 25, 2014, through April 23, 2014, and then weekly effluent sampling continued until the ISTT system shutdown on May 9, 2014. Effluent samples were submitted for the following laboratory analyses:

- VOC (USEPA TO-15)
- Reduced sulfur compounds (ASTM D5504)

The sampling and analysis plan addendum (CH2M HILL 2014a) outlined a weekly frequency for influent sample collection with a projected total of approximately 14 influent samples. Weekly influent samples were submitted for the following laboratory analysis:

- VOC (USEPA TO-15)
- Reduced sulfur compounds (ASTM D5504)
- British thermal unit determination (ASTM D3588)
- Oxygen, carbon dioxide, and nitrogen (fixed gases USEPA 3C)
- C1-C6 (hydrocarbon USEPA TO-3)

During ISTT operations, additional process vapor influent samples were collected throughout the pilot study to further evaluate and optimize system performance. Between March 14, 2014, and May 9, 2014, 40 influent process vapor samples were collected. The *In-Situ Thermal Treatment Pilot Study Report* (TerraTherm 2014) provided in Attachment 1 contains additional information pertaining to sample collection and ISTT performance based on analytical results.

In addition, Avogadro Environmental Corporation collected influent and effluent samples at the oxidizer inlet and effluent stack in accordance with the sampling and analysis plan (CH2M HILL 2013e) and January 2014 sampling and analysis plan addendum (CH2M HILL 2014a) to evaluate the presence of acid gases in vapor extracted from the caissons. Five acid sampling events were conducted throughout heating operations as outlined in the January 2014 sampling and analysis plan addendum (CH2M HILL 2014a). Vapor samples were collected using an impinger system that contained specific adsorbent solutions as generally defined by USEPA Method 26 and USEPA Method 8. Samples were subsequently submitted for analytical measurement in a fixed laboratory. Additional details regarding sample collection methods and procedures are discussed in the *Process Vapor Sampling Results for Pilot Study of In-Situ Thermal Treatment* (Avogadro 2014) provided in Attachment 6a.

In accordance with the sampling and analysis plan (CH2M HILL 2013e), influent and effluent samples were collected when the thermal oxidizer system was shut down and the backup treatment system was operating to assess efficacy of the unit operations and evaluate the viability of the process for use under a full-scale treatment scenario.

During the pilot study ISS phase, each caisson was fitted with a dedicated vapor extraction line to facilitate venting of headspace vapors from the caisson to the thermal oxidizer during ISS operations. Process vapor samples were collected from each vapor extraction line and from the thermal oxidizer effluent sample location in accordance with the May 2014 sampling and analysis plan addendum (CH2M HILL 2014b) and the

requirements of the EIPT permit equivalent issued by NJDEP on May 9, 2014 (EIP130002) (Table 1). Process vapor sampling during ISS operations included collecting one influent sample from Caisson 1 and one influent sample from Caisson 3 during primary ISS mixing operations on May 29 and May 30, 2014. In addition, one influent sample was collected from each Caisson (1, 2, and 3), and one effluent sample was collected from the thermal oxidizer discharge stack during curing. A summary of validated process vapor data is in Attachment 6a. A CD containing final laboratory data packages is in Attachment 7.

8.2 Waste Characterization

In accordance with the sampling and analysis plan (CH2M HILL 2014a), waste characterization sampling of process liquids and solids was conducted during pilot study operations.

A total of 42,219 gallons of scrubber blowdown water and 5,800 gallons of decontamination water was generated and disposed of as a non-RCRA DOT liquid at Environmental Recovery Corporation facility in Lancaster, Pennsylvania. A total of 7,107 gallons of caisson and cleaning water was generated and disposed as a RCRA hazardous liquid at Tradebe Environmental Services, LLC facility in Meriden, Connecticut. Appropriate disposal of remaining waste streams was determined based on the analytical results received.

Approximately 200 milliliters of organic condensate and 6 liters of aqueous condensate were generated during the pilot study. The original plan for condensate outlined in the October 2013 sampling and analysis plan (CH2M HILL 2013e) was to submit samples of condensate generated during the pilot study to the laboratory for chemical testing and to various reuse facilities to evaluate potential offsite disposal options. However, the volume of condensate generated during the pilot study was insufficient to complete this task.

Additional condensate from the treatability study has been retained at an offsite laboratory, and it was determined that quantities of condensate generated from the pilot study could potentially be combined with condensate from the treatability study to produce sufficient volume for subsequent testing and evaluation by reuse facilities. Therefore, samples of the organic and aqueous condensate generated during the ISTT phase of the pilot study were collected on July 10, 2014, and submitted to TestAmerica Laboratories for chemical analysis. In addition, samples of condensate from the treatability study were submitted to TestAmerica for chemical analysis. A summary of waste characterization data is provided in Attachment 2d. Waste characterization data collected during the pilot study were not validated. A CD containing unvalidated final laboratory data packages of waste characterization samples is in Attachment 7.

8.3 Corrosion Study

Because of the corrosive nature of material in Impoundment 2, a corrosion study was implemented during the pilot study to evaluate field corrosion rates for a range of construction materials under ambient and elevated temperature environments. Corrosion coupons were installed during construction of the ISTT system and then inspected following system shutdown.

To evaluate the effects of ISTT on construction materials, a series of metal samples were placed into the impoundment materials at various locations to evaluate corrosion. The materials tested were:

- A36 carbon steel
- 316 L stainless steel
- AL-2205
- SAF-2507
- AL6XN
- HASTELLOY C276

During design, five general exposure conditions were tested, as outlined below:

- Acid Tar – Impoundment material at ambient temperature (Caisson 1)

- Acid Tar less than 150 degrees Celsius – Impoundment material at central multi-phase extraction well (Caissons 2 and 3)
- Acid Tar greater than 150 degrees Celsius - Impoundment material along heater casing (Caissons 2 and 3)
- Liquid – Combined liquid stream extracted from Caissons 2 and 3
- Vapor – Individual vapor streams extracted from Caissons 2 and 3

Corrosion study results are graphically summarized in Attachment 6b. Materials tested are grouped by exposure condition, and the average corrosion rate in mills per year (shown on log scale) is presented on the horizontal axis. The exposure results of individual coupons also are provided for reference.

SECTION 9

References

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Tables

Table 1 - Summary of ISS Sampling Locations & Parameters
OU8 Pilot Study
American Cyanamid Superfund Site, Bridgewater, NJ

Revised **7/16/2014**

			CAISSON										ROLL OFF			
		Event ->	**Baseline Event**			**Vibracore Event 1 5/20/14**		**5/30/2014**	**Vibracore Event 2 5/30/14**		**ThermOx 6/2/14**		**6/4/2014**	**Grab Event 1 6/4/14**		**6/5/2014**	**Grab Event 2 6/5 & 6/6**	
		Treatement Stage ->	Baseline (Pre-ISTT)			Post Thermal (Pre-ISS Mix)			Pre-Cure		During Cure			Post Removal (Pre Secondary Mixing)			Post Secondary Mix (Pre-Cure)	
		Objective ->	Baseline			Evaluate Thermal Only Prior to Mixing			Evaluate Mixing and ISS Prior to Removal		Evaluate Vapors During Curing			Evaluate Mass Reduction Due to Removal			Evaluate Mass Reduction Due to Secondary Mixing	
Caisson 1 (ISS Only)	**Chemical (Accutest)/Physical (Kemron)**	**Method**						P					R			S		
	Hand Penetrometer (Field)	ASTM WK27337	1	✓				R	Multiple	✓			E	Multiple	✓	E	Multiple	✓
	Temperature (Field)	ASTM F542-07	1	✓				I	Multiple	✓			M	Multiple	✓	C	Multiple	✓
								M					O			O		
	TCL VOC	SW-846 8260B	1	✓		6	✓	A	2	✓			V	2	✓	N	2	✓
	TCL SVOC	SW-846 8270C	1	✓				R	2	✓			A	2	✓	D	2	✓
	TAL Metals	SW-846 6010C	1	✓				Y					L			A	1	✓
	TCLP - VOC, SVOC, Metals	SW-846 1311, 8260B, 8270C, 6010B, 7470A	1	✓				I	2	✓						R	1	✓
	SPLP - VOC, SVOC, Metals	SW-846 1312, 8260B, 8270C, 6010B, 7470A	1	✓				S	2	✓						Y	1	✓
	Acid Volatile Sulfide	USEPA Draft Method 1991				6	✓	S	2	✓				2	✓	M	1	✓
	pH/EH (ORP)/Acidity/Alkalinity	ASTM D1498-76/SW-846 9045C/SM 2310/SM20 2320	1	✓				M	2	✓						I	1	✓
								I								X		
								X								I		
	Moisture Content & Loss on Ignition	ASTM D2974	1	✓				I	2	✓						N	1	✓
	Bulk Unit Weight	ASTM D2726	1	✓				N	2	✓						G	1	✓
	Monolithic Leaching	ANSI 16.1						G	1	✓							1	✓
	UCS	ASTM D2166							2	✓							1	✓
Caisson 1 (ISS Only)	Hydraulic Conductivity	ASTM D5084							2	✓							1	✓
	Thermal Stability (Test America)																	
	PCBs	SW-846 Method 8082															1	✓
	Total Chlorine	SW-846 Method 9056															1	✓
	Total Bromine	SW-846 Method 9056															1	✓
	Total Fluorine	SW-846 Method 9056															1	✓
	Total Halogens	USEPA Method 300.0															1	✓
	Sulfides	SW-846 Method 9030B															1	✓
	Total Sulfur	SW-846 Method 9056A															1	✓
	Sulfur Forms - Total, Sulfate, Pyritic, Organic	ASTM D2492-02(2007)															1	✓
	Free Cyanide	ASTM D2492-02(2007)															1	✓
	Bulk Density	ASTM D2492-02(2007)															1	✓
Caisson 1 (ISS Only)	**DOT (UTEC)**																	
	Comustible Solids - UN Test N.1	UN Test Method N.1															1	✓
	Dangerous When Wet - UN Test N.5	UN Test Method N.5															1	✓
	Corrosivity (MB Research)	Corrositex Test															1	✓
	Emissions (Schmidt)																	
	Emissions Testing - In Caisson	TO-15/ASTM D5504				1 Simulation	✓											
	Emissions Testing - From Vibracore	TO-15/ASTM D5504				2 Simulations	✓							1 Simulation	✓		1 Simulation	✓
	Emissions Testing From Vibracore w/ Foam	TO-15/ASTM D5504				2 Simulations	✓							1 Simulation	✓		1 Simulation	✓
	Process Vapor (ALS)																	
	Influent - TO-15 & Total Reduced Sulfur	TO-15/ASTM D5504							1 @ lime addition 1 @ pozzalon mixing	✓	1 Isolated from Caisson 1 vapor line	✓						
	Effluent (weekly)	TO-15/ASTM D5504									1	✓						
	Additional Bench Scale Testing																	
	5-gallon buckets - Treatability Testing					5	✓											
	Bulk Density (Field)													1 Test	✓		1 Test	✓
	Cement Kilns																	
	Continental Cement Company 10107 Highway 79 Hannibal, MO 63401-7859													1 - 1-liter 1 - 5-gallon bucket	✓		10" x 4" Lexan Core	✓

Table 1 - Summary of ISS Sampling Locations & Parameters
OU8 Pilot Study
American Cyanamid Superfund Site, Bridgewater, NJ

Revised **7/16/2014**

			CAISSON								ROLL OFF	
		Event ->	**Baseline Event**			**Vibracore Event 1 5/27/14**		**ThermOx 6/2/14**		6/4/2014	**Grab Event 1 6/4/14**	
		Treatement Stage ->	Baseline (Pre-ISTT) Baseline			Post Thermal (Pre-ISS Mix)		During Cure of ISS Caissons			Post Removal	
		Objective ->				Evaluate Thermal Only Prior to Mixing		Evaluate Vapors During Curing			Evaluate Mass Reduction Due to Removal	
Caisson 2 (Thermal Only)	**Chemical (Accutest)/Physical (Kemron)**	**Method**										
	Hand Penetrometer (Field)	ASTM WK27337	1	✓		Multiple	✓				Multiple	✓
	Temperature (Field)	ASTM F542-07	1	✓		Multiple	✓				Multiple	✓
	TCL VOC	SW-846 8260B	1	✓		9	✓				2	✓
	TCL SVOC	SW-846 8270C	1	✓		9	✓				2	✓
	TAL Metals	SW-846 6010C	1	✓							1	✓
	TCLP - VOC, SVOC, Metals	SW-846 1311, 8260B, 8270C, 6010B, 7470A	1	✓		6	✓				2	✓
	SPLP - VOC, SVOC, Metals	SW-846 1312, 8260B, 8270C, 6010B, 7470A	1	✓		6	✓				2	✓
	Acid Volatile Sulfide	USEPA Draft Method 1991				9	✓				2	✓
	Total Sulfur	ASTM D129-95				9	✓				2	✓
	pH/EH (ORP)/Acidity/Alkalinity	ASTM D1498-76/SW-846 9045C/SM 2310/SM20 2320				6	✓				2	✓
	Moisture Content & Loss on Ignition	ASTM D2974				2	✓				2	✓
Caisson 2 (Thermal Only)	Bulk Unit Weight	ASTM D2726	1	✓		2	✓				2	✓
	Monolithic Leaching	ANSI 16.1				1	✓				1	✓
	UCS	ASTM D2166				2	✓				2	✓
	Hydraulic Conductivity	ASTM D5084				2	✓				2	✓
	Thermal Stability (Test America)											
	PCBs	SW-846 Method 8082									1	✓
	Total Chlorine	SW-846 Method 9056									1	✓
	Total Bromine	SW-846 Method 9056									1	✓
	Total Fluorine	SW-846 Method 9056									1	✓
	Total Halogens	USEPA Method 300.0									1	✓
	Sulfides	SW-846 Method 9030B									1	✓
	Total Sulfur	SW-846 Method 9056A									1	✓
	Sulfur Forms - Total, Sulfate, Pyritic, Organic	ASTM D2492-02(2007)									1	✓
	Free Cyanide	ASTM D2492-02(2007)									1	✓
	Bulk Density	ASTM D2492-02(2007)									1	✓
	DOT (UTEC)											
Caisson 2 (Thermal Only)	Comustible Solids - UN Test N.1	UN Test Method N.1									1	✓
	Corrosivity	Corrositex Test									1	✓
	Emissions (Schmidt)											
	Emissions Testing - In Caisson	TO-15/ASTM D5504				1 Simulation	✓					
	Emissions Testing - From Vibracore	TO-15/ASTM D5504				1 Simulation	✓					
	Emissions Testing From Vibracore w/ Foam	TO-15/ASTM D5504				1 Simulation	✓					
	Process Vapor (ALS)											
	Influent - TO-15 & Total Reduced Sulfur	TO-15/ASTM D5504						1 Isolated from Caisson 2 vapor line	✓			
	Effluent (weekly)	TO-15/ASTM D5504						1	✓			
	Additional Bench Scale Testing											
	Bulk Density (Field)										1 Test	✓
	Cement Kilns											
	Continental Cement Company 10107 Highway 79 Hannibal, MO 63401-7859										1 - 1-liter	✓

ISTT OPERATTION

REMOVAL

Table 1 - Summary of ISS Sampling Locations & Parameters
OU8 Pilot Study
American Cyanamid Superfund Site, Bridgewater, NJ

Revised **7/16/2014**

			CAISSON												ROLL OFF			
		Event ->	**Baseline Event**			**Vibracore Event 1 5/28/14**		**5/29/2014**	**Vibracore Event 2 5/29 & 5/30**		**ThermOx 6/2/14**		**6/4/2014**	**Grab Event 1 6/4/14**		**6/4/2014**	**Grab Event 2 6/4/14**	
		Treatement Stage ->	Baseline (Pre-ISTT)			Post Thermal (Pre-ISS Mix)			Pre-Cure (Day 0)		During Cure (Day 3 or 4)			Post Removal (Pre Secondary Mixing)			Post Secondary Mix (Pre-Cure)	
		Objective ->	Baseline			Evaluate Thermal Only Prior to Mixing			Evaluate Mixing and ISS Prior to Removal		Evaluate Vapors During Curing			Evaluate Mass Reduction Due to Removal			Evaluate Mass Reduction Due to Secondary Mixing	
Caisson 3 (Thermal & ISS)	**Chemical (Accutest)/Physical (Kemron)**	**Method**																
	Hand Penetrometer (Field)	ASTM WK27337	1	✓		Multiple	✓		Multiple	✓				Multiple	✓		Multiple	✓
	Temperature (Field)	ASTM F542-07	1	✓		Multiple	✓		Multiple	✓				Multiple	✓		Multiple	✓
	TCL VOC	SW-846 8260B	1	✓		9	✓		2	✓				2	✓		2	✓
	TCL SVOC	SW-846 8270C	1	✓		9	✓		2	✓				2	✓		2	✓
	TAL Metals	SW-846 6010C	1	✓													1	✓
	TCLP - VOC, SVOC, Metals	SW-846 1311, 8260B, 8270C, 6010B, 7470A	1	✓		6	✓		2	✓							1	✓
	SPLP - VOC, SVOC, Metals	SW-846 1312, 8260B, 8270C, 6010B, 7470A	1	✓		6	✓		2	✓							1	✓
	Acid Volatile Sulfide	USEPA Draft Method 1991				9	✓		2	✓				2	✓		1	✓
	pH/EH (ORP)/Acidity/Alkalinity	ASTM D1498-76/SW-846 9045C/SM 2310/SM20 2320				6	✓		2	✓							1	✓
	Moisture Content & Loss on Ignition	ASTM D2974				2	✓		2	✓							1	✓
	Bulk Unit Weight	ASTM D2726	1	✓		2	✓		2	✓							1	✓
	Monolithic Leaching	ANSI 16.1				1	✓		1	✓							1	✓
	UCS	ASTM D2166				2	✓		2	✓							1	✓
	Hydraulic Conductivity	ASTM D5084				2	✓		2	✓							1	✓
	Thermal Stability (Test America)																	
	PCBs	SW-846 Method 8082															1	✓
	Total Chlorine	SW-846 Method 9056															1	✓
	Total Bromine	SW-846 Method 9056															1	✓
	Total Fluorine	SW-846 Method 9056															1	✓
	Total Halogens	USEPA Method 300.0															1	✓
	Sulfides	SW-846 Method 9030B															1	✓
	Total Sulfur	SW-846 Method 9056A															1	✓
	Sulfur Forms - Total, Sulfate, Pyritic, Organic	ASTM D2492-02(2007)															1	✓
	Free Cyanide	ASTM D2492-02(2007)															1	✓
	Bulk Density	ASTM D2492-02(2007)															1	✓
	DOT (UTEC)																	
	Comustible Solids - UN Test N.1	UN Test Method N.1															1	✓
	Corrosivity	Corrositex Test															1	✓
	Emissions (Schmidt)																	
	Emissions Testing - In Caisson	TO-15/ASTM D5504				1 Simulation	✓											
	Emissions Testing - From Vibracore	TO-15/ASTM D5504				1 Simulation	✓							1 Simulation	✓		1 Simulation	✓
	Emissions Testing From Vibracore w/ Foam	TO-15/ASTM D5504				1 Simulation	✓							1 Simulation	✓		1 Simulation	✓
	Process Vapor (ALS)																	
	Influent - TO-15 & Total Reduced Sulfur	TO-15/ASTM D5504							1 @ lime addition 1 @ pozzalon mixing	✓	1 Isolated from Caisson 3 vapor line	✓						
	Effluent (weekly)	TO-15/ASTM D5504									1	✓						
	Additional Testing																	
	5-gallon buckets - Treatability Testing					5	✓											
	Bulk Density (Field)													1 Test	✓		1 Test	✓
	Cement Kilns																	
	Continental Cement Company 10107 Highway 79 Hannibal, MO 63401-7859																10" x 4" Lexan Core	✓
	Giant Cement Holding, Inc. 654 Judge Street Harleyville, SC 29448-3119																	

ISTT OPERATION

PRIMARY ISS MIXING

REMOVAL

SECONDARY MIXING

Figures

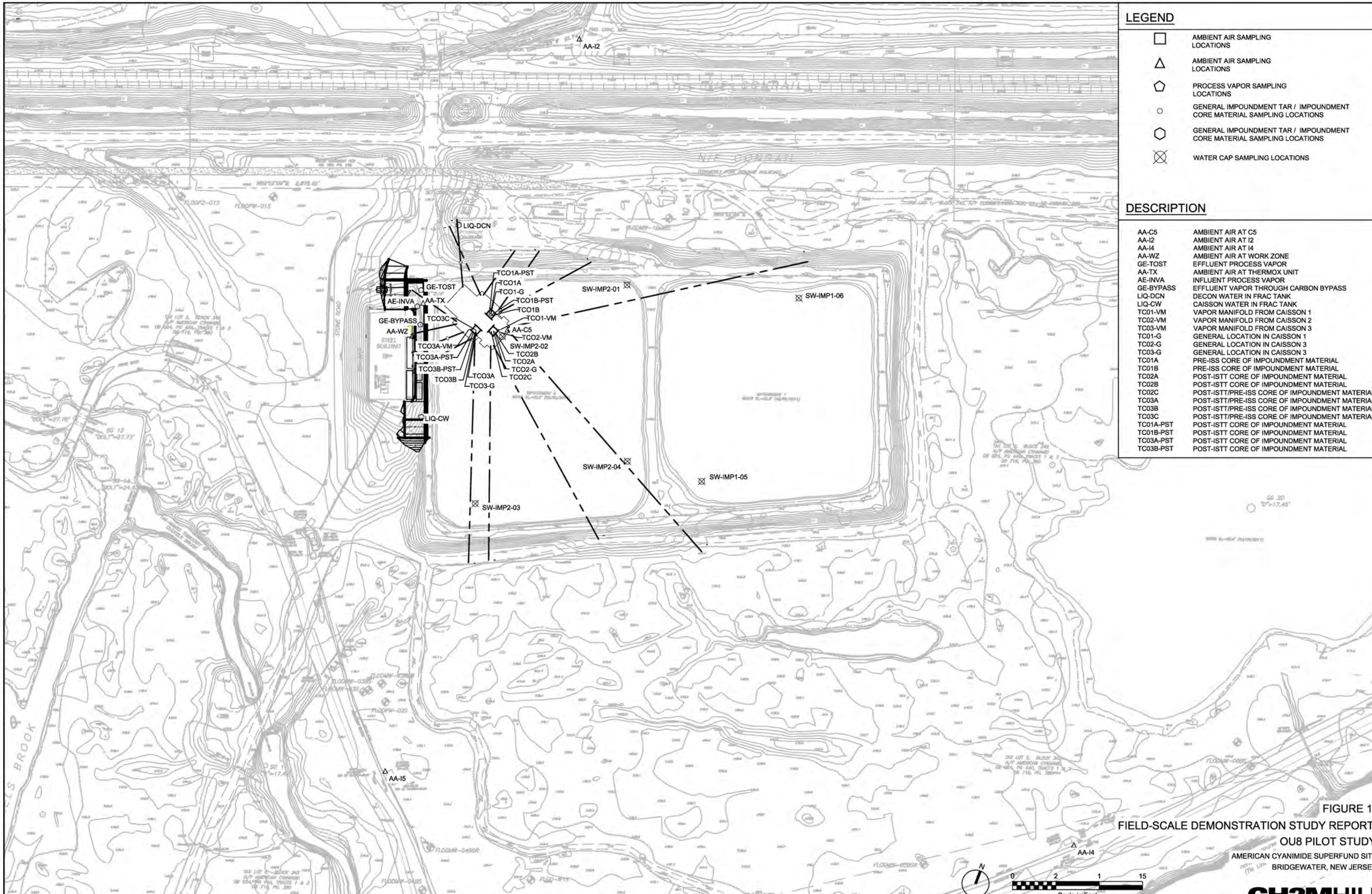


FIGURE 1
FIELD-SCALE DEMONSTRATION STUDY REPORT
OU8 PILOT STUDY
AMERICAN CYANIMIDE SUPERFUND SITE
BRIDGEWATER, NEW JERSEY

CH2MHILL.

Caisson #1

B A B A

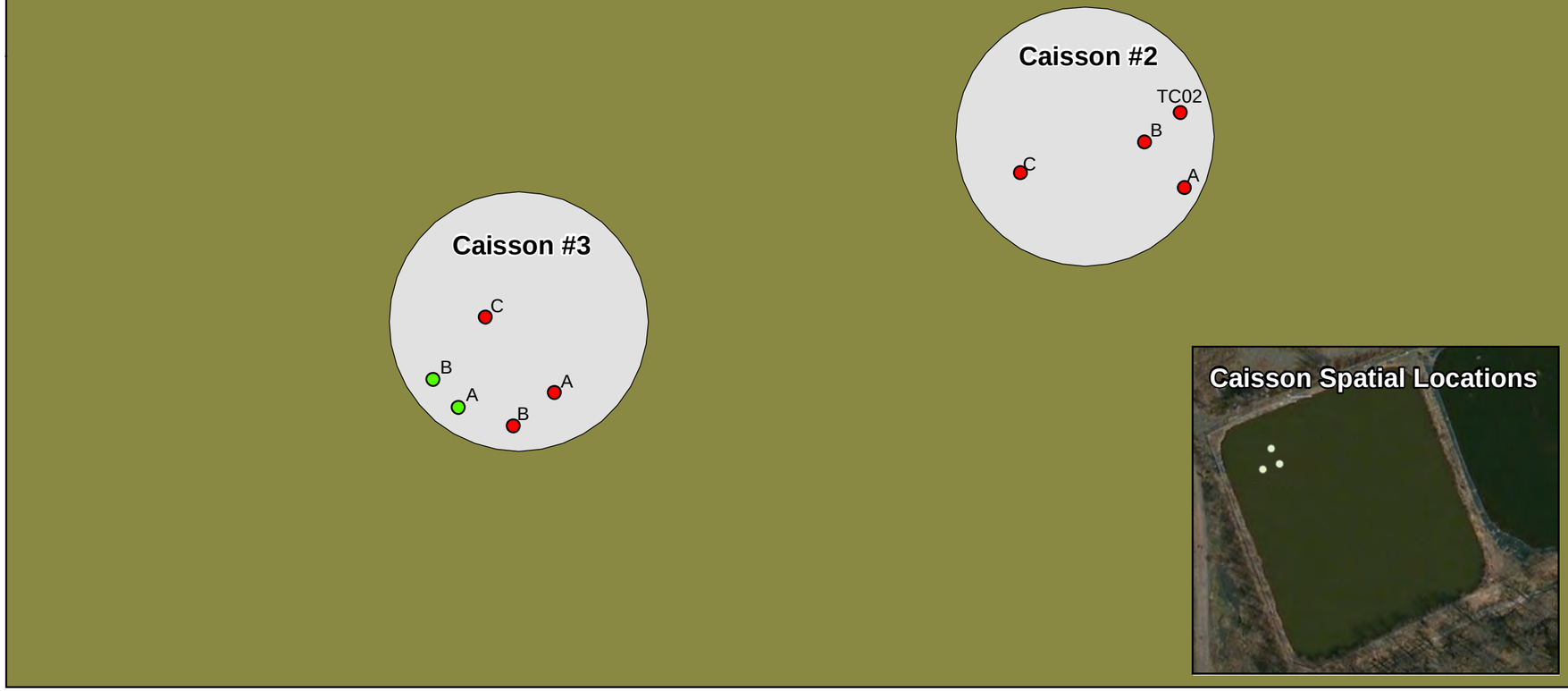
Caisson #2

TC02 B C A

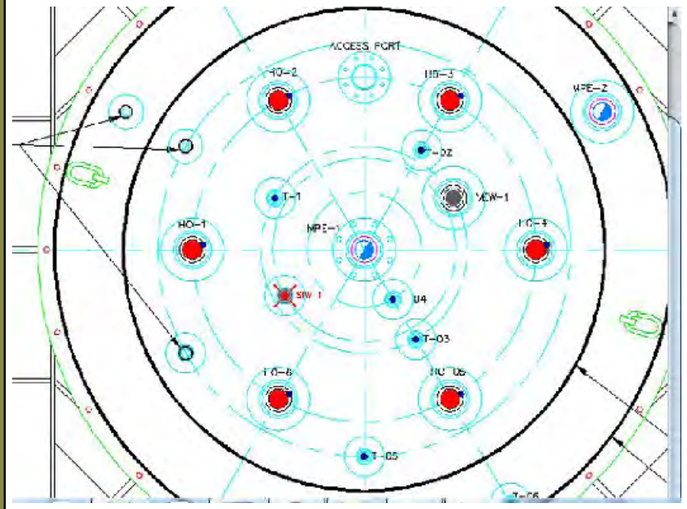
Caisson #3

C B A A B

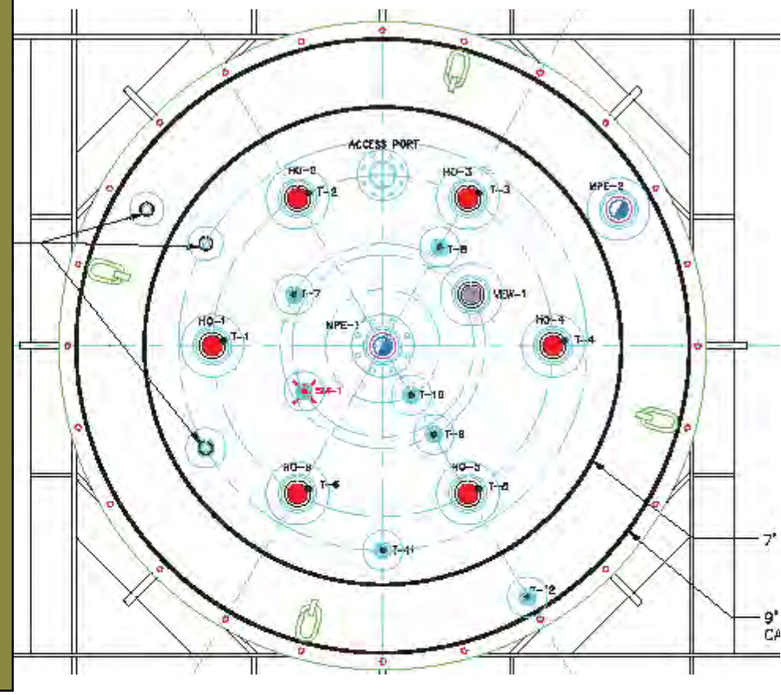
Caisson Spatial Locations



Caisson #2



Caisson #3



Legend

- Post-Mix Samples
- Pre-Mix Samples
- Caissons

0 5 10 20 Feet

N

Figure 2 - Impoundment Material Sample Locations
American Cyanamid OU8 Pilot Study
Bridgewater, NJ
May, 2014

CH2MHILL